Strategy Research Project

A Strategic Approach for Space Acquisition

by

Lieutenant Colonel Timothy Rade
United States Air Force

United States Army War College
Class of 2012

DISTRIBUTION STATEMENT: A
Approved for Public Release
Distribution is Unlimited

The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)* 14-03-2012	**2. REPORT TYPE** Strategy Research Project	**3. DATES COVERED** *(From - To)*
4. TITLE AND SUBTITLE A Strategic Approach for Space Acquisition		**5a. CONTRACT NUMBER**
		5b. GRANT NUMBER
		5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) Lieutenant Colonel Timothy Rade		**5d. PROJECT NUMBER**
		5e. TASK NUMBER
		5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Lieutenant Colonel Greg Hillebrand Department of Military Strategy, Planning, and Operations		**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army War College 122 Forbes Avenue Carlisle, PA 17013		**10. SPONSOR/MONITOR'S ACRONYM(S)**
		11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Distribution A: Approved for public release. Distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The impending federal budget reduction is a watershed event for the Department of Defense (DoD) and presents the DoD with an opportunity to implement a new strategic approach for managing its space acquisition portfolio. The looming funding reduction, in concert with emerging guidance from senior leadership and strong Congressional criticism of space programs, have significantly altered the strategic environment for space acquisition. The DoD must take advantage of this new environment to fundamentally reshape how it acquires space capabilities for the nation. The DoD needs a new strategic approach founded on three lines of effort. The DoD must develop and communicate a prioritized investment plan, change how it manages space program requirements, and pursue new space mission architectures that use small satellites. These recommendations will synchronize efforts across the space acquisition community to make it more efficient and improve program cost and schedule performance. It will make our space mission architectures more resilient to technical problems or adversary action. Finally, this strategic approach will reduce Congressional criticism and increase their support for national security space programs.

15. SUBJECT TERMS

Investment Plan, Requirements Management, Small Satellites

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT UNCLASSIFED	**b. ABSTRACT** UNCLASSIFED	**c. THIS PAGE** UNCLASSIFED	UNLIMITED	32	**19b. TELEPHONE NUMBER** *(include area code)*

USAWC STRATEGY RESEARCH PROJECT

A STRATEGIC APPROACH FOR SPACE ACQUISITION

by

Lieutenant Colonel Timothy Rade
United States Air Force

Lieutenant Colonel Gregory Hillebrand
Project Adviser

This SRP is submitted in partial fulfillment of the requirements of the Master of Strategic Studies Degree. The U.S. Army War College is accredited by the Commission on Higher Education of the Middle States Association of Colleges and Schools, 3624 Market Street, Philadelphia, PA 19104, (215) 662-5606. The Commission on Higher Education is an institutional accrediting agency recognized by the U.S. Secretary of Education and the Council for Higher Education Accreditation.

U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

ABSTRACT

AUTHOR: Lieutenant Colonel Timothy Rade

TITLE: A Strategic Approach for Space Acquisition

FORMAT: Strategy Research Project

DATE: 14 March 2012 WORD COUNT: 6,506 PAGES: 32

KEY TERMS: Investment Plan, Requirements Management, Small Satellites

CLASSIFICATION: Unclassified

The impending federal budget reduction is a watershed event for the Department of Defense (DoD) and presents the DoD with an opportunity to implement a new strategic approach for managing its space acquisition portfolio. The looming funding reduction, in concert with emerging guidance from senior leadership and strong Congressional criticism of space programs, have significantly altered the strategic environment for space acquisition. The DoD must take advantage of this new environment to fundamentally reshape how it acquires space capabilities for the nation. The DoD needs a new strategic approach founded on three lines of effort. The DoD must develop and communicate a prioritized investment plan, change how it manages space program requirements, and pursue new space mission architectures that use small satellites. These recommendations will synchronize efforts across the space acquisition community to make it more efficient and improve program cost and schedule performance. It will make our space mission architectures more resilient to technical problems or adversary action. Finally, this strategic approach will reduce Congressional criticism and increase their support for national security space programs.

A STRATEGIC APPROACH FOR SPACE ACQUISITION

> Virtually all aspects of military operations are affected in some way by the capabilities provided by space…it's difficult to overstate their importance to the success of our Armed Forces.
>
> —General Norton Schwartz[1]

The impending federal budget reduction is a watershed event for the Department of Defense (DoD) and presents the DoD with an opportunity to implement a new strategic approach for managing its space acquisition portfolio. These looming funding reductions, in concert with emerging guidance from senior leadership and strong Congressional criticism of space programs, have significantly altered the strategic environment for space acquisition. The DoD must take advantage of this new environment to fundamentally reshape how it acquires space capabilities for the nation. The DoD needs a new strategic approach founded on three lines of effort. The DoD must develop and communicate a prioritized investment plan, change how it manages space program requirements, and pursue new space mission architectures that use small satellites. These recommendations will synchronize efforts across the space acquisition community to make it more efficient and improve program cost and schedule performance. It will make our space mission architectures more resilient to technical problems or adversary action. Finally, this strategic approach will reduce Congressional criticism and increase their support for national security space programs.

The DoD space acquisition community must provide capabilities across a wide array of missions and deal with challenging technical problems. The strategic acquisition approach that the space acquisition community developed over time was predicated on three key tenets.

> The U.S. Government followed a strategy for National Security Space programs that relied on (1) budgets large enough to solve impossible problems, (2) a close working relationship with industry to develop programs that would meet extraordinary technical challenges, and (3) satellites designed 'better than spec' that could last longer than expected, which provided a cushion while policymakers debated the next generation of replacement programs.[2]

Given that the first assumption is no longer true, the space acquisition community must adopt a new strategic approach.

For the purposes of this paper, the space acquisition community is defined in the broadest sense. This community includes the government program office team and their industrial partners that design, procure, build and test the systems. It also includes the key staffs that provide oversight during the acquisition process on behalf of the senior decision makers, the staffs that generate and approve the requirements, and the staffs that advocate for program resources. This paper will focus on space acquisition issues at the broadest levels and not delve into specific mission or program issues. It will specifically not focus on acquisition process improvements, due to the extensive research already published. This paper will focus on key processes that support space acquisition and key technical developments that may influence mission architectures.

The space acquisition community has a broad scope of responsibility, since the portfolio of space missions is quite extensive. Joint doctrine describes four space mission areas: space control, space force enhancement, space force application, and space support.[3] These four mission areas are then further broken down into specific missions and functions. Space control includes offensive space control, defensive space control and space situational awareness. Space force enhancement includes missile warning, intelligence, surveillance and reconnaissance, environmental monitoring, satellite communications, and space-based positioning, navigation & timing.

Space force application includes intercontinental ballistic missiles (ICBMs). Space support includes spacelift operations and satellite operations.[4]

Specific space programs provide capability in these mission areas. In some cases, multiple space programs support specific mission requirements. For example, the communications mission has three major programs providing capabilities for secure communications, high data rate communications, and low data rate communications to mobile users. Space-based Intelligence collection has several programs providing various imagery and signals intelligence. Space situational awareness includes multiple programs to search for, detect, track and characterize space objects. To place satellites into their required orbits, spacelift requires launch vehicle programs, launch ranges and associated launch infrastructure programs. In general, space force enhancement programs field a constellation of satellites, a ground command and control system to operate the satellites, and ground-based user terminals to receive the mission data from the satellites. Space support programs and most space control programs field ground systems and infrastructure. All of these space programs are complex and expensive – often in the billions of dollars per program.

Sustaining this large portfolio of space missions is greatly complicated by the physics of operating in space. The program offices must design their satellites to withstand extreme temperature ranges and harsh radiation conditions. These difficult conditions limit the operational lifetime of satellites, which range from five to fourteen years, depending on the mission. The physics of space also create unique engineering design challenges, the need for special space-rated parts, and specialized assembly integration and test approaches. Once launched, the program office cannot recover the satellite and “return it to depot” for repair – typically driving the program office to incorporate significant subsystem redundancy and fault management systems to monitor and react to on-orbit problems. The satellites frequently operate longer than their design lives, due to conservative engineering by the program office and innovative approaches by the operations teams to squeeze residual capability out of the systems.[5]

At some point, the harsh physics of space catch up to all satellites. The satellite runs out of fuel to maintain its orbit or subsystems fail after prolonged exposure to radiation. This dynamic creates a never-ending requirement to constantly replenish the satellite constellations. This replacement rate is substantially higher than for terrestrial military systems like aircraft, ships and ground vehicles. As an example, the B-52 bomber was first fielded in 1955 and has been in continuous service for 57 years.[6] This stands in stark contrast to the five to fourteen year replenishment rates for satellites. This has had a direct effect on space acquisition strategies, often driving programs to design larger, more complex satellites with longer design lives in order to reduce the constellation replenishment rate.

Like their predecessors, the current space acquisition community will continue to manage an extensive portfolio of missions and design programs to operate in the harsh conditions of space. However, the past acquisition approach that relied on large budgets for the development of large, complex space systems is going to have to change. Significant changes to the strategic environment for space acquisition will force a new strategic approach to providing national security space capabilities. Framing this strategic environment helps provide context to the situation and allows leadership to properly define the problem the new strategy will address.[7]

For space acquisition, three major environmental factors influence this recommended new strategic approach. First, the space acquisition community will have reduced financial resources to execute programs. Second, senior leadership recently provided strategic guidance to the space acquisition community. Finally, space acquisition programs will continue to come under close Congressional scrutiny for the foreseeable future. These three factors together must drive the space acquisition community to pursue a new approach to providing national security space capabilities.

The most significant current environmental factor for the space acquisition community is the upcoming budget reduction. Per the Budget Control Act signed by President Obama, the DoD must reduce funding by $487 Billion over the next ten years, with the possibility of further reductions.[8] Because the Congressional Joint Select Committee on Deficit Reduction failed to agree on an additional $1.2 Trillion in debt reduction measures, the DoD budget will face sequestration, taking additional budget cuts between $500-600 Billion over 10 years starting in fiscal year 2013.[9] The Total Obligation Authority (TOA) for space acquisition programs will decrease significantly. In Fiscal Year 2012, the TOA for Defense space programs is $10.2 Billion.[10] For Fiscal Year 2013, the President requested $8.0 Billion, a 22% reduction.[11] These long-term budget cuts are going to force the space acquisition community to prioritize efforts and develop more cost effective capabilities across the space mission areas.

To develop more cost effective space capabilities, the space acquisition community is going to have to overcome the strong bias within the DoD for large, complex acquisition programs. As former Secretary of Defense James Schlesinger noted,

> When (Secretary of Defense) McNamara introduced the Planning, Programming and Budgeting system…he proceeded to use that system…to determine precisely the force structure for the services. Yet, when he prescribed force structure, he created an overwhelming incentive for the services to drive-up per unit costs. Their goal, no doubt, was to get as much capability as one could into each force unit. Yet by driving up per unit costs, it moved us further along the road, later caricatured, of a military establishment ultimately consisting of one aircraft, one ship and one tank…The services feared that if they designed cheaper capabilities they would simply lose resources[12]

The space community suffers from these same issues. Challenging technical problems and the high cost of launch incentivized the space acquisition community to develop small constellations of large and complex satellites, which drove historically large funding requirements.

Pejoratively called "Battlestar Galacticas" – military space systems frequently weigh over 10,000lbs and are the size of school busses. These large systems are very complex – increasing the likelihood of technical or production issues that delay the fielding of the system. These delays drive up program costs and impact the warfighter. In a letter to President Obama, the Committee for U.S. Space Leadership commented that "we face near-term mission gaps in important space capabilities…there is wide-spread program overreach – recurring cost overruns and delays, and more government space programs than the federal budget can currently support."[13] The space acquisition community must adopt more executable approaches to fielding space capabilities, in order to minimize cost and schedule growth and avoid future capability gaps.

The second significant environmental factor is the recent guidance from senior leadership. Secretary of Defense Gates, in his 2011 National Security Space Strategy, described space as "vital to U.S. national security" and "driven by three trends – space is increasingly congested, contested, and competitive."[14] With approximately 60 nations and government consortia operating over 1,100 active satellites, space is becoming more congested. More than 22,000 pieces of space debris threaten the safe operation of those satellites. Space is also now a contested domain -- “potential adversaries are seeking to exploit perceived space vulnerabilities.” U.S. space systems face a range of man-made threats, including the anti-satellite system tested by China in 2007.[15] Finally, competition is increasing as these other nations grow their space expertise to compete with the U.S. space industrial base. In addition, the long development cycles and inconsistent acquisition rates for U.S. Government space programs further stress our domestic industry. These issues challenge the ability of the U.S. to maintain assured access to space and overall space leadership.[16]

In response to these trends, the National Security Space Strategy outlines several objectives for the space acquisition community. First, it calls for the community to “identify…and prioritize investments in those capabilities that garner the greatest advantages.”[17] Second, it calls for improved management and evaluation of requirements, to ensure a range of affordable solutions is considered.”[18] Third, it calls for a “mix of capabilities with shorter development cycles to minimize delays, cut cost growth and enable more rapid technology maturation.”[19] Finally, it calls for strengthening the resilience of our space architectures to deny the adversary the benefit of attack.[20] These objectives form the basis for the strategic approach recommended in this paper.

General William Shelton, the Commander of Air Force Space Command, expanded further on the guidance from the National Security Space Strategy. He noted that our nation’s “dependence on space is high, higher than it’s ever been for sure within DoD…our vulnerability in space is increasing…and our budgets will be at best flat."[21] He challenged the space acquisition community to develop space mission architectures that provide adequate capability, resiliency, and can remain within budget. Looking for "just good enough capability, rather than pushing the state of the art,"[22] he wants higher mission resiliency. "We can't tolerate the loss of mission critical capability …whether due to intentional (adversary action) or…due to technical difficulties."[23] He called for disaggregated constellations – distributing sensors and capabilities across satellite networks instead of consolidating significant capabilities on small numbers of large systems, which become difficult to replace if lost.[24]

The final strategic environmental factor is significant Congressional scrutiny of space acquisition programs. Over the last ten years, poor performance on numerous space programs has generated significant attention from Congress. Having grown accustomed to frequent space program failures, Congress has the space acquisition community on a short leash and is quick to react. This has led to dramatically increased reporting requirements, tighter program oversight, and the loss of Congressional support and funding. Responding to this increased oversight requires significant effort and attention and creates a more difficult environment for the space acquisition community to successfully execute current and future space programs. The DoD must improve space acquisition performance in order to regain Congressional trust. Through improved program performance, the space acquisition community can positively influence their strategic environment. Congressional support for space programs would increase. In addition, Congress may relax their reporting requirements and oversight, which would reduce the workload on the space acquisition community and potentially improve their ability to execute their space programs.

As part of this increased oversight, Congress has tasked the Government Accountability Office (GAO) to investigate several space programs. The GAO found that "despite the significant investment in space, the majority of large-scale acquisition programs in DoD's space portfolio have experienced problems during the past two decades that have driven up costs by hundreds of millions and even billions of dollars and stretched schedules by years and increased technical risks…Significant schedule delays of as much as 9 years have resulted in potential capability gaps in missile warning, military communications, and weather monitoring."[25] In order to address the cost increases, the DoD has reduced the quantity of satellites, reduced satellite capabilities or terminated some satellite programs. These acquisition issues force the warfighter to assume increased risk because of reduced capabilities and more fragile space mission architectures that rely on fewer satellites.

In addition, the GAO has identified significant issues with the DoD's approach to space acquisition. First, the "Department of Defense starts more weapon systems than it can afford, creating a competition for funding that encourages low cost estimating and optimistic scheduling".[26] Second, it "starts its space programs too early, before it has assurances the capabilities it is pursuing can be achieved within available resources and time constraints."[27] Third, "programs have historically attempted to satisfy all requirements in a single step."[28]

> The DoD has preferred to make fewer but heavier, larger, and more complex satellites that perform a multitude of missions rather than larger constellations of smaller, less complex satellites that gradually increase in sophistication...Programs seek to maximize capability on individual satellites because it is expensive to launch.[29]

Congress tracks these GAO criticisms and requires the space acquisition community to provide frequent program status reports and periodic assessments on how well they are improving the acquisition process. In addition, senior space leaders must testify frequently before key Congressional Committees. In recent testimony, Major General John Hyten, Director of Space Programs for the Assistant Secretary of the Air Force (Acquisition), acknowledged that space acquisition programs were criticized for "overreaching" – that the systems in development promised "giant single-step leaps in technology, but often overran program budgets and failed to meet requirements in a timely manner."[30] He did note that despite these challenges, the space acquisition community has delivered remarkable new capabilities. Several 1st of their generation space systems promise significant upgrades over legacy systems.[31] Major General Hyten stressed the need to "fundamentally change the way we do business in space acquisition… adopting a back to basics approach through clear and achievable requirements, disciplined systems engineering, proven technology, and appropriate resourcing.[32] However, until the space acquisition community generates a better program execution record, increased Congressional scrutiny and significant DoD efforts expended to address that scrutiny will continue for the foreseeable future.

Given these three strategic environmental factors, the space acquisition community must alter their approach for developing and fielding national security space capabilities. Declining financial resources and senior leader guidance will push the space acquisition community to explore more resilient and cost effective architectures. Continued strong Congressional criticism will drive the community to find approaches that improve space program execution. The DoD must define a strategic approach that will be successful within this strategic environment.

As one former senior space acquisition leader commented, “A good strategy should drive investment decisions…strategy needs to link policy to budget.”[33] The DoD should pursue three lines of effort in the new strategic approach for space acquisition. First, leadership needs to identify space mission investment priorities and communicate those priorities across the space acquisition community. Second, the DoD needs to revamp its requirements process in order to improve program execution. Finally, program offices need to explore mission architectures of small satellites to improve program cost and schedule performance and to increase mission resiliency.

Identify and Communicate the Investment Plan. The space acquisition community needs the equivalent of a Commander’s Intent that specifies prioritized investment across the space missions. After developing their prioritized investment plan, leadership must then communicate this space investment guidance across the space community. By communicating investment priorities, the space acquisition community can synchronize efforts across the program offices and staffs to operate more efficiently and effectively. Without those priorities clearly understood, the space acquisition community will continue to manage their portfolio of programs inefficiently.

Lacking specific long-term investment guidance, each program works under the premise that it is the most critical and seeks to gain more resources. This often comes at the expense of other missions. Well-intentioned staffs and program offices identify new mission requirements, new operating concepts, new vulnerabilities and threats, and new mission recapitalization needs. These promise improved capability or increased operational effectiveness, but require investment funding and personnel. Similarly, when programs have cost, schedule or technical issues, their default position is to pursue additional resources for the program. This creates enormous workloads on the staffs and program offices as they justify the program need and compete for finite resources. This also ties up the staffs and senior leadership in never-ending, program-by-program tactical resourcing decisions with little guidance on where the priority of effort should be. This is an inefficient use of manpower and tends to “peanut butter” spread available financial and personnel resources across all programs. A prioritized investment plan would limit the options and the time spent on handling resource issues for lower priority missions. It could reduce the manpower required in the program offices and staffs to support these lower priority programs. A prioritized investment plan focuses available financial and personnel resources on the priority missions.

When the space acquisition community understands which missions have priority and which are in a strategic hold, they can synchronize the efforts of the staffs and acquisition program offices and make the acquisition processes more efficient. For example, leadership could place a priority on developing alternative launch vehicles options in order to reduce launch costs, declare a “strategic pause” for precision navigation and timing, or take added risk in the wideband communications mission because of the availability of commercial alternatives. The program offices and staffs now understand where the priority lies for investing in new capabilities and which missions must hold the line. Senior leadership will be in a better position to properly assess requirements and resource needs across the mission areas. With a stable investment strategy, they can judge when to approve difficult technical requirements and apply additional resources in priority areas and when to hold the line on resources and requirements for lower priority mission areas.

Though the DoD recently generated a "15 Year Defense Space Systems Investment Strategy," it does not fully address the strategic approach described in this paper.[34] This strategy was in response to Congressional direction in the 2010 National Defense Appropriations Act. It essentially describes the current space programs of record as the investment plan for each space mission area and identifies decision points for replacement programs. Though the document is a reasonable starting point, it has two shortfalls. First, leadership has not widely disseminated this document to communicate their investment plan. It took repeated efforts to track down a copy of the document and few space acquisition professionals had insight into the contents. Second, this strategy does not provide investment prioritization by space mission. Lacking clear guidance on investment priorities, the space acquisition community cannot have unity of effort.

Since Congress requires the DoD to update this space investment strategy biannually, there is an opportunity to build off this initial effort and develop a truly prioritized investment plan. DoD space leadership will have to make tough choices. They will need to consult with the space user community to analyze threats, gaps, vulnerabilities and opportunities, and then compare that to available resources. Through this approach, they can prioritize the list of space missions and programs and then communicate that list across the space acquisition community. From this prioritized list, the space acquisition community will be able to synchronize efforts and apply resources more appropriately across the program portfolio. In addition, program execution should improve as requirements and resources align with program priority. As space program performance improves, Congressional criticism will recede and the DoD will gain increasing Congressional support for national security space programs.

Revamp Requirements Management. The second line of effort to improve space acquisition is to improve requirements management. The DoD needs to revise the requirements approval process, manage requirements using a portfolio-wide approach, and reduce the number of program requirements. By revamping the requirements processes in these ways, the space acquisition community would be responding to the Secretary of Defense's call to improve requirements management in order to provide a range of affordable program options. Limiting requirements to only essential capability needs and then prioritizing them across the portfolio would focus programs on the important system attributes and prevent requirements growth. This would help control program costs and improve program execution. Improved program execution will increase Congressional support for national security space programs.

The current requirements approval process is difficult to get through and susceptible to requirements creep. As one senior acquisition leader observed, "gaining consensus on mission requirements is extremely difficult. In two years, we could not get agreement on what the requirements for space situational awareness would be. We had paralysis by analysis."[35] Others issued similar complaints. In 2008, the GAO found that the requirements "process has proven to be lengthy – taking an average of 10 months to validate a need, which further undermines efforts to effectively respond to the needs of the warfighter."[36] A recent Army study determined that the average time to approve program requirements ranged from 15 to 22 months, depending on the size of the acquisition program.[37] The cumbersome requirements approval process adds to the lengthy acquisition process and puts space missions at risk. “You have 10-15 year on-orbit satellite lifetimes coupled to 10-15 year requirements and acquisition processes. It leaves little margin for error and makes it difficult to do technology refresh for these missions.”[38] Given the finite on-orbit lifetimes, these delays eat into schedule margins the program office has to develop and field the replacement systems and endangers the continuous flow of space products that the warfighter relies on.

In Congressional testimony, several acquisition experts point to the requirements process as a significant problem with DoD acquisition. Former Deputy Secretary of Defense Rudy De Leon attributed 50% of program cost overruns to requirements creep. The GAO’s acquisition reform expert, Paul Francis, also attributed most program cost growth to requirements creep. These experts called for the DoD to reform this process to reduce the number of “real requirements” and delineate true requirements from negotiable objectives. “Requirements become almost holy writ during programs” and become major drivers of program complexity, cost and schedule.[39]

In April 2011, the DoD announced that it is overhauling its requirements process, known as the Joint Capabilities Integration & Development System (JCIDS). JCIDS has been described as ponderously slow and unable to align requirements to the acquisition and budget processes.[40] General James Cartwright, Vice Chairman of the Joint Chiefs of Staff, stated “we’re starting to rewrite JCIDS… we’re going to align ourselves with acquisition and three levels of risk.” Details of the revamped process are in work, but the intent is to allow “three tiers of capability based on the urgency of need and time to fielding.”[41] Tier one requirements would be for urgent needs requiring expedited procurement. Tier two would cover mid-term needs requiring some development. Tier three would be used for long-term needs requiring riskier research and development.[42] This new tiered requirements structure allows a more strategic approach to managing requirements. By understanding senior leadership investment priorities, the acquisition program offices and staffs can place certain missions in certain requirement tiers. This would synchronize operational requirements with the appropriate acquisition risk level and approach. Lower risk requirements would lead to rapid “off-the-shelf” procurements. Higher risk requirements would lead to significant research and development efforts and long duration programs. Through this tiered requirements approach, the operations and acquisition communities would more closely align their program funding, schedule and technical expectations.

In addition to tiered requirements, the DoD needs to pursue a portfolio-wide requirements management approach, aligned with leadership’s prioritized investment plan. Currently, each mission independently pursues ever-increasing requirements. This leads to complex space programs that strain available funding resources. However, leadership-directed mission priorities allow optimized requirements across the portfolio. After careful study with key stakeholders, leadership can prioritize the missions that must pursue more advance capabilities and identify the missions that must hold requirements to their current capabilities. This will require difficult decisions and entail spirited debate. Those space professionals and space data users from the “losing” mission areas will not like the decisions. The DoD has weathered this before, during the rise and fall of “bomber and fighter mafias” within the Air Force and surface and aviation communities within the Navy. The time has come for similar hard choices within the space community. We simply cannot afford to invest in ever increasing capabilities across the board in all space missions. Where we have adequate capacity and capability, we must hold the line on requirements. Where we see significant capability gaps or threats, we must invest in advanced capabilities.

Today's requirements management approach also exacerbates space acquisition program execution issues. The ever-increasing requirements for individual missions drive new capability needs – yet available funding cannot support separate programs for all these missions. The space acquisition community merges these requirements into large, multi-mission satellite programs. They have now boxed themselves into a corner – tying too many requirements across too many missions onto single systems. These highly complex programs often experience cost, schedule or technical difficulties. Yet they cannot delete requirements or recommend program termination – because there are no other alternatives for these missions. Senior leadership is left with few, if any, options other than to take resources from other space programs in order to keep funding the troubled program. This creates a ripple effect, as the "sourced" program loses resources and has to reduce the quantity or delay delivery of its system, drawing increased Congressional criticism. By managing requirements at the portfolio level, we can curtail uncontrolled mission requirements growth and minimize the complexity and number of multi-mission satellite programs. Simpler programs will greatly improve the space acquisition community's ability to execute programs.

Finally, the DoD needs to reduce the number of program requirements to only the essential system capabilities. Current program requirements documents are typically quite extensive, listing several key performance parameters (KPPs) and hundreds of additional detailed, lower priority program requirements. Each requirement has a threshold and an objective value – providing trade space for the acquisition program offices to work within.[43] Program offices focus on meeting the KPPs, because the program may be cancelled if it does not meet KPP threshold values. However, the sheer number of non-KPP requirements creates great strain on an acquisition program. Many of these requirements are added during the review process to address the interests of various DoD constituencies. Their continued advocacy for the program is contingent on meeting these lower priority requirements.

These numerous lower priority requirements can over-constrain the program office and limit flexibility in meeting the military need. In one example, a government acquisition expert testified to Congress that a "program had 35 non-negotiable requirements and 800 'negotiable' requirements. I would respectfully submit…that when you have 800 of anything they aren't requirements."[44] Former senior DoD acquisition leader David Chu suggested that "the system should back away from using the term requirements, except when it really is a requirement. Much of what we pursue is actually technology objectives."[45] The requirements process would produce better solutions if program requirements were kept at the system level and limited to 5 to 10 KPPs and 40 to 50 total program requirements. All other 'requirements' should become program objectives. This approach would allow the program office to provide a greater range of innovative options across the cost versus capability trade space.

The Operationally Responsive Space – 1 (ORS-1) program is a recent example of using this minimal requirements approach. ORS-1 is a medium resolution imagery satellite and associated ground systems to support a U.S. Central Command urgent need. Lacking the time to coordinate a detailed JCIDS requirements document, Air

Force Space Command rapidly coordinated high level program requirements with U.S. Strategic Command, U.S. Central Command and the ORS Office. The program had 17 program requirements; only 3 were the equivalent of key performance parameters.[46] Less critical program objectives used phrases like ‘to the maximum extent possible, the program should __.’

By minimizing formal requirements to just the essential ones, the program had the flexibility to make timely decisions and tradeoffs. Because these changes did not impact the 17 system level requirements, the program office did not require formal milestone decision authority approval to change lower level technical specifications. “The small, focused set of requirements was instrumental to the speed and agility of the program. The ORS-1 program successfully delivered all program requirements in record time and at an affordable cost.”[47] By focusing the ORS-1 requirements on a small set of essential program capabilities, the acquisition team was able to develop and field an innovative solution. This met the mission need while doing it more rapidly and at a greatly reduced cost compared to large, complex programs.

Small Satellite Mission Architectures. The final line of effort for a new space investment strategy is to examine alternative mission architectures that use small satellites. Small satellites weigh between 500-1000 kilograms and provide reasonable capabilities, at affordable costs, and build resilience into our mission architectures.[48] They also have shorter development cycles and would allow more rapid technology upgrades within mission areas. In parallel with the improvements in small satellite capabilities, the DoD has been pursuing new small and medium launch vehicle capabilities. These new systems make the cost of launch more affordable and alter the calculus for architecting space missions.

Until recently, small satellites were not capable of meeting most operational missions. Typically, small satellites were used for on-orbit research and development or to fill niche operational missions. Mainstream operational space requirements typically drove solutions that needed small constellations of large, complex satellites in order to perform the mission. The launch costs for those large satellites were often in excess of $150 Million.[49] The need for large satellites and the high launch costs drove the space acquisition community to maximize the capabilities on those systems, often integrating multiple payloads onto the satellites. The incremental cost of launching a separate satellite to provide additional capability was cost prohibitive, compared to simply ‘upgrading’ the main payload to provide more advanced capabilities or adding secondary payloads to perform other missions. However, the complexity of these large multi-mission systems contributed significantly to the frequent cost, schedule and technical issues encountered during the acquisition. In addition, the high launch and satellite costs drove the mission architectures to small numbers of satellites. This created relatively fragile mission architectures. Vulnerable to enemy action and susceptible to technical issues, the loss or partial failure of a single satellite would have serious impact to a mission.

The calculus for designing space mission architectures is now changing. ORS-1 demonstrated that small satellites are now capable enough to meet national security needs. ORS-1 was put into early operational use shortly after launch.[50] Although not as technically capable as the larger systems, recent informal polls of the space operations and intelligence communities suggest that they are pleased with the performance of the ORS-1 system. This “good enough” capability can be delivered at a fraction of the cost and time of nominal large systems. The program office launched ORS-1 in 32 months, versus the typical 7-10 years for large systems. While the DoD has not released the costs publicly, one report suggested that it was ~10 times less expensive to launch than traditional large imagery systems.[51] These cost and schedule advantages align with the Secretary of Defense’s guidance in his National Security Space Strategy for a “mix of capabilities with shorter development cycles to minimize delays, cut cost growth, and enable more rapid technology maturation.”[52] These advantages will also help reduce Congressional criticism and increase Congressional support for space programs.

With improved military utility of small satellites, the space acquisition community must explore new mission architectures. Large constellations of small satellites would provide two major advantages. First, the mission architectures would be more resilient – larger constellations would be far less affected by the loss or degradation of individual satellites due to technical issues or enemy action. Constellations of small satellites, using downsized payloads, may provide overlapping and complementary sensor coverage. By combining their capabilities, large constellations of small satellites can produce the same capability and capacity as large satellites. The second advantage of small satellite architectures is that they enable more rapid fielding of new technologies. Their shorter mission design lives and lower production costs allow a program to incorporate advances in payload capabilities more rapidly than current large satellite architectures. With much longer design lives and much higher costs, large satellites are fielded in fewer numbers and replaced more slowly. This slows the ability to field new capabilities to support the warfighter.

Transitioning to constellations of small satellites will require careful planning. The DoD will "need to double down on a space mission – investing in development of the small satellite architecture while simultaneously continuing the large satellite program of record."[53] Certain missions may be more appropriate than others for this approach. The low data rate mobile user communications mission has already experimented with small satellites. Missile warning may be another mission appropriate for small satellites. The requirements community will need to segregate missile warning requirements from the battlespace characterization requirements that were merged into the current multi-mission satellite system. A constellation of small missile warning satellites augmented with a few larger satellites with advanced battlespace characterization payloads may be more cost effective than the current expensive multi-mission system.

Not all missions may be suitable for small satellite constellations. For some missions, physical and technical constraints may dictate the need for large payloads, requiring large satellites. For others, the cost may increase if they move from the current architecture to larger constellations of small satellites. However, in these cases, the space acquisition community can still leverage small satellites to improve program performance. DoD acquisition instructions require programs to develop prototypes as part of their acquisition strategy.[54] These prototypes validate technological maturity before the program is authorized to move forward with development. Small satellites would allow the program office a relatively inexpensive way to build, launch and test key spacecraft and payload subsystems before committing to significant development costs on large operational satellite programs.

New affordable launch vehicle options are also changing the calculus for space mission architectures, by driving down launch costs and enabling large constellations of small satellites. The DoD and Orbital Sciences Corporation have developed a series of ICBM-based small launch vehicles. The Minotaur I and IV launch vehicles can place small satellites into low earth orbit and have had 23 successful launches and a 100% success rate.[55] Currently under development, the Minotaur V will launch a small satellite to geosynchronous transfer orbits. From there, the satellite can raise its orbit to geosynchronous altitudes, which are important for communications, missile warning and other key satellite missions. Space Exploration Technologies, known as SpaceX, is also fielding several launch vehicles to compete with the existing launch industry. Their Falcon 1e launch vehicle can place a small satellite into low earth orbit. The Falcon 9 launch vehicle has substantial capability and can place multiple small satellites into either low earth orbit or geosynchronous transfer orbit. NASA has already contracted with SpaceX to resupply the International Space Station.[56] Currently, SpaceX is in the process of building a strong flight safety track record in order to compete for high value national security space missions.

As the Minotaur and Falcon launch vehicle families become reliable launch options, larger satellite constellations become feasible because the cost to launch to low earth orbit or geosynchronous transfer orbit becomes much more affordable. The Minotaur launch costs run $30-50 Million dollars, depending on configuration and launch range.[57] SpaceX costs range from $11 Million per Falcon 1e to $59 Million per Falcon 9 launch vehicle.[58] This represents a significantly cheaper option than the cost of larger Atlas or Delta launch vehicles from the United Launch Alliance, which typically cost over $150 Million.[59] This will make larger constellations of small satellites viable options for mission architectures. It is also possible to “stack” multiple small satellites onto one launch vehicle to efficiently and cost-effectively replenish these large constellations.

The improvements in small satellites and launch vehicles will drive programs to explore migrating from current large satellite mission architectures. Small satellites and launch vehicles are relatively simpler systems to produce – they cost less and require shorter development schedules. They are less risky acquisitions that will minimize the risk of delays and cost growth. Large constellations of these small satellites provide resilience to our mission architectures and enable more rapid technology upgrades to the missions.

In the end, the impending federal budget reductions will force the Department of Defense to make significant changes to its space acquisition approach. The constrained fiscal environment, new guidance from senior leadership and strong Congressional criticism of space acquisition has significantly altered the strategic environment for the space acquisition community. In response to this new environment, the three lines of effort described in this paper provide an executable new strategic approach to space acquisition that will produce considerable benefit. The DoD must develop and communicate a prioritized investment plan, change how it manages space program requirements, and pursue new mission architectures that use small satellites. This new approach will synchronize efforts across the space acquisition community, making it more efficient and improving program execution. This approach also addresses senior leadership guidance to pursue cost-effective architectures that provide reasonable capability and resiliency, while minimizing the risk of cost and schedule growth. If successfully executed, this strategic approach would reduce Congressional criticism of space acquisition and gain increased Congressional support for space programs.

Endnotes

[1] General Norton Schwartz, U.S. Air Force Chief of Staff, *"Chief of Staff highlights importance of space to Air Force mission,"* Defense Media Activity-San Antonio, February 19, 2010.

[2] Rick Larned, Cathy Swan, and Peter Swan, *National Security Space Strategy Considerations* (n.p., Lulu.com, 2010), 5.

[3] U.S. Joint Chiefs of Staff, *Space Operations*, Joint Publication 3-14 (Washington DC: U.S. Joint Chiefs of Staff, January 9, 2009), II-1.

[4]Ibid., v.

[5] Larned, Swan, and Swan, *National Security Space Strategy Considerations*, 7.

[6] U.S Air Force Webpage, "B-52 Stratofortress Factsheet," December 29, 2011, http://www.af.mil/information/factsheets/factsheet.asp?id=83 (accessed February 12, 2012).

[7] U.S. Army War College Department of Military Strategy, Planning, and Operations, *Campaign Planning Handbook Academic Year 2012 (Carlisle Barracks, PA: U.S. Army War College, n.d.), 2*9-33.

[8]Scott Wilson and Greg Jaffe, "In Creating New Defense Strategy, Obama Attempts to Outflank Congress," January 7, 2012, http://www.washingtonpost.com/national/national-security/in-creating-new-defense-strategy-obama-attempts-to-outflank-congress/2012/01/06/gIQAIjrQhP_story.html, (accessed January 22, 2012).

[9] Jim Garramone, "Panetta Tells Senators Sequestration Would Devastate DoD," November 15, 2011, http://www.defense.gov/news/newsarticle.aspx?id=66094, (accessed January 22, 2012).

[10] Office of the Under Secretary of Defense (Comptroller), *U.S. Department of Defense Fiscal Year 2012 Budget Request Overview* (Washington DC: U.S. Department of Defense, February 2011), 4-8.

[11] Office of the Under Secretary of Defense (Comptroller), *Program Acquisition Costs By Weapon System* (Washington DC: U.S. Department of Defense, February 2012), 7-1.

[12] James Schlesinger, "The Office of the Secretary of Defense," in *Reorganizing America's Defense: Leadership in War and Peace*, edited by Robert J. Art, Vincent Davis, and Samuel Huntington (Washington, DC: Pergamon-Brassey's, 1985), 268.

[13] Larned, Swan, and Swan, *National Security Space Strategy Considerations*, 2.

[14] Robert M. Gates and James R. Clapper, *National Security Space Strategy Unclassified Summary* (Washington DC: U.S. Department of Defense, January 2011), 1.

[15] Ibid., 2-3.

[16] Ibid., 3.

[17] Ibid., 6.

[18] Ibid., 7.

[19] Ibid.

[20] Ibid., 10-11.

[21] General William L. Shelton, U.S. Air Force, "Remarks from the 27th National Space Symposium," April 16, 2011, www.afspc.af.mil/library/speeches/speech.asp?id=646, (accessed February 7, 2012).

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] U.S. Government Accountability Office, *Space Acquisitions: DoD Poised to Enhance Space Capabilities, but Persistent Challenges Remain in Developing Space Systems* (Washington DC: U.S. Government Accountability Office, March 10, 2010), 1.

[26] Ibid., 10.

[27] Ibid.

[28] Ibid.

[29] Ibid.

[30] Major General John E. Hyten, "Challenges in Military Space Acquisition," *Hampton Roads International Security Quarterly 11, no. 3* (July 1, 2011): 48.

[31] Ibid.

[32] Ibid.

[33] Larned, Swan, and Swan, *National Security Space Strategy Considerations*, 9.

[34] U.S. Department of the Air Force, *15 Year Defense Space Systems Investment Strategy FY2012-2026* (Washington DC: U.S. Department of the Air Force, August 16, 2011), 2.

[35] Colonel Carol Welsch, U.S. Air Force, Deputy Director, Space Development and Test Division, telephone interview by author, November 4, 2011.

[36] U.S. Government Accountability Office, *DoD's Requirements Determination Process Has Not Been Effective in Prioritizing Joint Capabilities* (Washington DC: U.S. Government Accountability Office, September 25, 2008), 3.

[37] U.S. Department of the Army, *Final Report of the 2010 Army Acquisition Review* (Washington DC: U.S. Department of the Army, January 2011), xii.

[38] Lieutenant Colonel George Nagy, U.S. Air Force, Command Lead, Operationally Responsive Space Requirements, Headquarters Air Force Space Command, telephone interview by author, November 2, 2011.

[39] Colin Clark, "Fix Requirements, You Fix Costs," April 30, 2009, http://www.dodbuzz.com/2009/04/30/fix-requirements-you-fix-costs/ (accessed February 12, 2012).

[40] Michael Cadenazzi and J. Michael Barrett, "Rationalizing Requirements," September 6, 2010, http://www.defensenews.com/apps/pbcs.dll/article?AID=20109060314 (accessed February 12, 2012).

[41] Amy Butler, "Pentagon Overhauling Requirements Process," April 15. 2011, http://www.aviationweek.com/aw/generic/story.jsp?id=news/asd/2011/04/15/02.xml&headline=Pentagon%20Overhauling%20Requirements%20Process&channel=defense (accessed February 12, 2012).

[42] Ibid.

[43] U.S. Joint Chiefs of Staff, *Manual for the Operation of the Joint Capabilities Integration and Development System* (Washington DC: U.S. Joint Chiefs of Staff, January 19, 2012), B-A-1.

[44] Clark, "Fix Requirements, You Fix Costs."

[45] Ibid.

[46] Craig Howe, Program Manager, Operationally Responsive Space – 1, telephone interview by author, December 2, 2011.

[47] Ibid.

[48] Dr. Peter Wegner, Director, Operationally Responsive Space Office, telephone interview by author, February 1, 2012.

[49] Colonel Burke E. Wilson and Colonel Jeff Haymond, "Operationalizing Small Space: Challenges of Moving from Research, Development, Test and Evaluation to Operations," *High Frontier 6, no. 3* (May 2010): 19.

[50] General William L. Shelton, Commander, Air Force Space Command, "ORS-1 Satellite Early Combatant Command (COCOM) Acceptance," memorandum for Commander, U.S. Strategic Command, Colorado Springs, CO, September 29, 2011.

[51] Strategy Page, "The Little Keyhole That Could", July 1, 2011, http://www.strategypage.com/htmw/htspace/20110701.aspx, (accessed February 12, 2012).

[52] Gates and Clapper, *National Security Space Strategy*, 7.

[53] Wegner, telephone interview by author, February 1, 2012.

[54] Under Secretary of Defense for Acquisition, Technology & Logistics, *Operation of the Defense Acquisition System*, Department of Defense Instruction 5000.02 (Washington DC: Office of the Secretary of Defense, December 8, 2008),13.

[55] Orbital Sciences Corporation webpage, http://www.orbital.com/spacelaunch/minotaur/ (accessed December 2, 2011).

[56] Space Exploration Technologies webpage, http://www.spacex.com/launch_manifest.php (accessed February 16, 2012).

[57] Spaceflight Now webpage, http://spaceflightnow.com/minotaur/stps26/101118preview/ (accessed December 6, 2011).

[58] Space Exploration Technologies webpage, http://www.spacex.com/ falcon9.php#pricing_and_performance (accessed February 16, 2012).

[59] Wilson and Haymond, "Operationalizing Small Space," 19.